



# Bordetella pertussis IgA/IgG/IgM ELISA

## CONTENTS

- 1 INTENDED USE
- 2 BACKGROUND
- 3 TEST PRINCIPLE
- 4 KIT COMPONENTS
- 5 MATERIAL REQUIRED BUT NOT SUPPLIED
- 6 STORAGE AND STABILITY
- 7 TEST PROCEDURE
  - 7.1 Evidence of Deterioration
  - 7.2 Sample Preparation and Storage
  - 7.3 Preparation of Kit Reagents
  - 7.4 Overview - Test Procedure
  - 7.5 Manual Test Procedure
  - 7.6 Automated Test Procedure
  - 7.7 Positive Control / Accuracy Control
- 8 TEST EVALUATION
  - 8.1 Criteria of Validity
  - 8.2 Cut-off Calculation
  - 8.3 Borderline Ranges
- 9 PERFORMANCE CHARACTERISTICS
  - 9.1 Sensitivity and Specificity
  - 9.2 Reproducibility
- 10 SAFETY MEASURES
  - 10.1 Statements of Warning
  - 10.2 Disposal
- 11 REFERENCES

**For Research Use  
Only – Not for Use  
in Clinical  
Procedures**

# IBL-America Bordetella pertussis IgA/IgG/IgM ELISA

## Enzyme-immunoassay for the determination of human antibodies

<b>Bordetella pertussis IgA ELISA</b>	Order No.: IB05010
<b>Bordetella pertussis IgG ELISA</b>	Order No.: IB05011
<b>Bordetella pertussis IgM ELISA</b>	Order No.: IB05012

## For Research Use Only – Not for Use in Clinical Procedures

### 1 INTENDED USE

The IBL-America Bordetella pertussis IgA, IgG and IgM ELISA tests are qualitative immunoassays for the detection of human antibodies in serum or plasma directed against *Bordetella pertussis* and *Bordetella parapertussis*. These assays are recommended for the sensitive detection of such antibodies in various kinds of samples.

### 2 BACKGROUND

*Bordetella pertussis* belongs to the genus of *Bordetella*. It is a small coccoid, gram negative bacillus, which occurs world-wide. *Bordetella pertussis* is the causative agent of whooping cough, a globally occurring infectious disease that is transmitted from person to person by droplet infection. Children up to the age of 4 years are particularly affected and the mortality in infected infants is high (60 % of deaths occur within the first year after birth). Infections with *B. parapertussis* result in a less severe form of the disease.

The attachment of *B. pertussis* and *B. parapertussis* to the ciliated cells in the mucosa of the human respiratory tract is mediated by adhesins. An important adhesion protein and an equally important immunogen is the so-called filamentous haemagglutinin (FHA).

Colonisation of the respiratory tract and establishment of infection are facilitated by the synergistic action of several virulence factors. An important virulence factor is pertussis toxin (PT) which mediates multiple biological effects such as leukocytosis, lymphocytosis, mitogenicity, and increased sensitivity to histamine.

The use of ELISAs for the detection of specific antibodies is the current method of choice for the measurement of antibodies, e.g. antibodies against the filamentous haemagglutinin (FHA) which are produced in response to contact with *Bordetella pertussis* and *Bordetella parapertussis*. As a consequence of this cross reactivity, an immune response to the group-specific antigen provides evidence of contact with Bordetella pathogen.

### **3 TEST PRINCIPLE**

The ELISA (Enzyme Linked Immunosorbent Assay) is an immunoassay, which is particularly suited to the determination of antibodies in the field of infectious serology. The reaction is based on the specific interaction of antibodies with their corresponding antigen. The test strips of the microtiter plate are coated with specific antigens of the pathogen of interest. If such antibodies in the sample are present, they bind to the fixed antigen. A secondary antibody, which has been conjugated with the enzyme alkaline phosphatase, detects and binds to the immune complex. The colourless substrate p-nitrophenylphosphate is then converted into the coloured product p-nitrophenol. The signal intensity of this reaction product is proportional to the concentration of the analyte in the sample and is measured photometrically.

#### 4 KIT COMPONENTS

Test Components	Pieces / Volume
<b>Break apart microtiter test strips each with eight antigen coated single wells,</b> (altogether 96) <b>[MTP]</b> , 1 frame. The coating material is inactivated.	12 pieces
<b>Standard serum (ready-to-use) [STD]</b> , Human serum in protein containing phosphate buffer; negative for anti-HIV Ab, HBs-Ag (Hepatitis B-Virus surface antigen) and anti-HCV Ab; preservative: < 0.1 % sodium azide; colouring: Amaranth O	2 x 2 ml
<b>Negative control serum (ready-to-use) [NEG]</b> , Human serum in protein containing phosphate buffer; negative for anti-HIV Ab, HBs-Ag (Hepatitis B-Virus surface antigen) and anti-HCV Ab; preservative: < 0.1 % sodium azide; colouring: Lissamin Green V	2 ml
<b>Anti-human IgA, IgG or IgM conjugate (ready-to-use) [APC]</b> , Anti-human IgA, IgG or IgM polyclonal antibody, conjugated to alkaline phosphatase, stabilised with protein stabilisation solution; preservative: < 0.1 % methylisothiazolone, < 0.1 % bromnitrodioxane	13 ml
<b>Washing solution concentrate (sufficient for 1000 ml) [WASH]</b> , Sodium chloride solution with Tween 20 and 30 mM Tris/HCl, pH 7.4; preservative: < 0.1 % sodium azide	33.3 ml
<b>Dilution buffer (ready-to-use) [DILB]</b> , Protein containing phosphate buffer with Tween 20; preservative: < 0.1 % sodium azide; colouring: 0.01 g/l Bromphenol blue	2 x 50 ml
<b>Stopping solution (ready-to-use) [STOP]</b> , < 0.1 N sodium hydroxide, 40 mM EDTA	15 ml
<b>Substrate (ready-to-use) [pNPP]</b> , Para-nitrophenylphosphate in solvent free buffer; preservative: < 0.1 % sodium azide	13 ml
<b>Quality control certificate</b>	1 page

#### 5 MATERIAL REQUIRED BUT NOT SUPPLIED

- Common laboratory equipment
- For the IgM detection: Rf-Absorbent, order no. IB05998 (20 ml)
- Photometer for microtiter plates with filter, wavelength 405 nm, recommended reference wavelength 620 nm - 690 nm (e.g. 650 nm)
- Microtiter plate washer
- Incubator 37 °C
- Moist chamber
- Distilled water

## 6 STORAGE AND STABILITY

Reagent	Storage	Stability
Microtiter strips (coated with antigen)	unopened after opening at 2 – 8 °C in closed aluminum bag with desiccant	see expiry date 6 months
Control sera / Standard sera	Unopened after opening at 2 – 8 °C	see expiry date 6 months
Conjugate	Unopened after opening at 2 – 8 °C	see expiry date 6 months
Dilution buffer	Unopened after opening at 2 – 8 °C	see expiry date 6 months
Washing solution	unopened / after opening at 2 – 8 °C working dilution at 2 – 8 °C working dilution at room temperature	see expiry date 2 weeks 1 week
Substrate	Unopened after opening at 2 – 8 °C	see expiry date 6 months
Stopping solution	Unopened after opening at 2 – 8 °C	see expiry date 6 months

## 7 TEST PROCEDURE

### 7.1 Evidence of Deterioration

Optimum results can only be achieved if the instructions are strictly followed. The components must not be exchanged for reagents of other manufacturers. Standard and control sera are defined exclusively for the test kit to be used and must not be used in other lots. Washing solution, substrate and stop solution can be used for all IBL-America ELISA immunoassays coded IB05xxx irrespective of the lot and the test.

Each IBL-America ELISA coded IB05xxx contains a ready-to-use sample dilution buffer. In some cases the use of special dilution buffers is necessary to guarantee consistent quality and reliable results. The dilution buffers can be used irrespective of the lots.

There are three different conjugate concentrations for each immunoglobulin class (IgA, IgG, IgM), indicated on the label as + (low), ++ (medium) and +++ (high). Conjugates with the same concentration and of the same immunoglobulin class are interchangeable and can be used for other IBL-America ELISAs coded IB05xxx irrespective of the lot and the test. Dilution or alteration of the reagents may result in a loss of sensitivity. Use aseptic techniques when removing aliquots from the reagent tubes to avoid contamination.

Reproducibility of test results is dependent on thorough mixing of the reagents. Agitate the flasks containing control sera before use and also all samples after dilution (e.g. by using a vortex mixer).

Be sure to pipette carefully and comply with the given incubation times and temperatures. Significant time differences between pipetting the first and last well of the microtiter plate when dispensing samples and control sera, conjugate or substrate can result in different pre-incubation times, which may influence the precision and reproducibility of the results. Avoid exposure of reagents to strong light during storage and incubation.

Adequate washing avoids test unspecificities. Therefore, the washing procedure should be carried out carefully. All of the flat bottom wells should be filled with equal volumes of washing buffer. At the end of the procedure ensure that the wells are free of all washing buffer in order to avoid uncontrolled dilution effects. Avoid foaming!

Reagents must be tightly closed after use to avoid evaporation and contamination. Take care not to mix-up the caps of the bottles and/or vials.

The result of these ELISA testkits only valid if the lot-specific validation criteria on the quality control certificate are fulfilled.

## 7.2 Sample Preparation and Storage

Lipaemic, hemolytic or icteric samples (serum or plasma) should only be tested with caution. Obviously contaminated samples should not be tested. Serum or plasma (EDTA, citrate, heparin) collected according to standard laboratory methods are suitable samples. Samples must not be thermally inactivated.

### 7.2.1 Dilution of Samples

Before running the test, all samples ( $V_1$ ) must be diluted in dilution buffer ( $V_2$ ) as follows:

#### **Bordetella pertussis IgA/IgG ELISA**

$V_1 + V_2 = 1+100$	add	10 $\mu$ l	sample
		each to 1000 $\mu$ l	dilution buffer

## **Bordetella pertussis IgM ELISA**

### Interference with rheumatoid factors

Rheumatoid factors are autoantibodies mainly of the IgM class, which preferably bind to IgG immune complexes. The presence of non-specific IgM antibodies (rheumatoid factors) can lead to false-positive results in the IgM assay. Furthermore, the possibility exists, that weak-binding pathogen-specific IgM antibodies may be displaced by stronger-binding IgG antibodies leading to a false-negative IgM result. Therefore it is necessary to pretreat samples with rheumatoid factor-absorbents prior to IgM detection (Rf-Absorbent). Rf-absorption is performed by incubation of the sample in Rf-dilution buffer for 15 minutes at room temperature or over night at 4 °C. The test procedure is described in a separate instruction manual.

Before running the test, rheumatoid factor-absorbent ( $V_1$ ) must be diluted 1+4 in dilution buffer ( $V_2$ ).

$V_1 + V_2 = V_3 (1 + 4)$	add	200 $\mu$ l	Rf-absorbent
	to each	800 $\mu$ l	dilution buffer

Samples ( $V_4$ ) must be diluted in this Rf-dilution buffer ( $V_3$ ):

$V_4 + V_3 = 1+100$	add	10 $\mu$ l	sample
	to each	1000 $\mu$ l	Rf-dilution buffer

After dilution and before pipetting into the microtiter plate the samples must be mixed thoroughly to prepare a homogenous solution.

### **7.2.2 Sample Storage**

The samples should not be stored for more than 7 days at 2 – 8 °C. Extended storage is possible at  $\leq -20$  °C. Avoid repeated freezing and thawing of samples. Diluted samples can be stored at 2 – 8 °C for one week.

### 7.3 Preparation of Kit Reagents

Bring all reagents to room temperature before testing.

#### 7.3.1 Microtiter Test Strips

The microtiter test strips labeled with abbreviations for pathogen and immunoglobulin class are packed with a desiccant in an aluminum bag. To open the aluminum bag of the microtiter plate please cut off the top of the marked side only, in order to guarantee proper resealing. Take unrequired cavities out of the frame and put them back into the aluminum bag. Close bag carefully to ensure airtight conditions. Do not use the strips if the aluminum bag is damaged or if the bag with remaining strips and desiccant was not properly resealed.

#### 7.3.2 Control Sera / Standard Sera (ready-to-use)

Control and standard sera are ready-to-use and must not be diluted any further. For each test run - independent of the number of microtiter test strips to be used - control and standard sera must be included. Standard and cut off sera should be set up in duplicate. Do not treat control sera with Rf-absorbent.

#### 7.3.3 Anti-human IgA, IgG or IgM AP-Conjugate (ready-to-use)

The required conjugate concentration (+, ++, +++) is indicated on the quality control certificate. Please refer also to the specification on the label.

#### 7.3.4 Washing Solution (Concentrate)

Dilute washing buffer concentrate ( $V_1$ ) 1:30 with aqua dest. to a final volume of  $V_2$ .

Example:

Buffer concentrate ( $V_1$ )	Final volume ( $V_2$ )
33.3 ml	1000 ml
1.0 ml	30 ml

#### 7.3.5 Dilution Buffer for Samples (ready-to-use)

#### 7.3.6 Substrate (ready-to-use)

Substrate in unopened bottle may have a slightly yellow coloring, which does not reduce the quality of the product!

#### Stopping Solution (ready-to-use)



## Overview - Test Procedure

### IBL-America Bordetella pertussis IgA/IgG/IgM ELISA

In case of IgM detection absorption of rheumatoid factor, see No. 7.2.1;  
Incubation 15 minutes at room temperature or over night at 4°C

sample dilution<sup>1</sup>  
1+100

Pipette diluted samples and ready-to-use control /  
standard sera into the microtest wells (100 µl)



INCUBATION 60 min./ 37 °C  
moist chamber



WASH (4 x 300 µl [DIL] [WASH] )<sup>2</sup>



Pipette conjugate solution [APC] (100 µl)



INCUBATION 30 min./ 37 °C  
moist chamber



WASH (4 x 300 µl [DIL] [WASH] )<sup>2</sup>



Pipette substrate solution [pNPP] (100 µl)



INCUBATION 30 min./ 37 °C  
moist chamber



Pipette stopping solution [STOP] (100 µl)



READ EXTINCTION at 405 nm

<sup>1</sup>Special dilution buffers for the following IBL-America ELISA tests:  
Borrelia burgdorferi IgG, IgM Epstein-Barr Virus EA IgG

<sup>2</sup>For manual use:  
tap plate at the end of the wash procedure on paper towel.

## 7.4 Manual Test Procedure

1. Place the required number of **cavities in the frame** and prepare a protocol sheet.
2. Add each **100 µl of diluted sample or ready-to-use control/standard sera** into the appropriate wells of microtiter test strips. Spare one well for substrate blank, e.g.:

Well	Component
A1	substrate blank
B1	negative control
C1	standard serum
D1	standard serum
E1	sample 1 ...
F1	sample 2 ...

3. **Sample incubation** for 60 minutes (+/- 5 min.) at 37 °C (+/- 1°C) in moist chamber
4. After incubation **wash** all wells with washing solution (by automated washer or manually):
  - aspirate or shake out the incubation solution
  - fill each well with 300 µl washing solution
  - aspirate or shake out the washing buffer
  - repeat the washing procedure 3 times (altogether 4 times!)
  - dry by tapping the microtiter plate on a paper towel
5. **Addition of conjugate**  
Add 100 µl of the ready-to-use IgA/IgG/IgM conjugate to the appropriate wells (except substrate blank)
6. **Conjugate incubation** for 30 minutes (+/- 1 min.) at 37 °C (+/- 1 °C) in moist chamber.
7. After incubation **wash** all wells with washing solution (see above).
8. **Addition of substrate**  
Add 100 µl of ready-to-use substrate solution to each well (including well for substrate blank!)
9. **Substrate incubation** for 30 minutes (+/- 1 min.) at 37 °C (+/- 1 °C) in moist chamber.
10. **Stopping of the reaction**  
Add 100 µl stopping solution to each well, shake microtiter plate gently to mix.
11. **Read extinction**  
Read optical density (OD) within 60 minutes at 405 nm against substrate blank, reference wave length between 620 nm and 690 nm (e.g. 650 nm).

## **7.5 Automated Test Procedure**

The ELISA are validated for use with Immunomat (using the following consumables: VT124, VT111, VT112) and suited for processing on similar analyzers. For processing on the Immunomat the current software version including reagent check has to be used. The automated processing is performed analogous to manual use. Please note, that under special working-conditions internal laboratory adaptations of the substrate incubation times may be necessary.

## **7.6 Positive Control / Accuracy Control**

For the periodic verification of the test method, in order to fulfil the requirements of laboratory internal quality management systems, we recommend using IBL-America ELISA controls (cat.-no. IB05xxxCON, see also chapter 5) to determine precision and accuracy of the test runs. The use of these ELISA controls is described in specific instruction manuals.

## **8 TEST EVALUATION**

For the qualitative interpretation of serum samples a lot specific correction factor as well as a lot specific grey zone is calculated by manufacturer for each kit lot. These values can be found on the lot specific quality certificate included in each test kit.

For test run control a standard serum is used in each individual test run. For this control serum a reference value with a validity range is determined by the quality control of the manufacturer. Within this range a correct cut-off interpretation is ensured.

### **8.1 Criteria of Validity**

The substrate blank must be  $< 0.25$  OD

The negative control must produce a negative test result.

The mean OD-value (after subtraction of the substrate blank!) of the standard serum must be within the validity range, which is given on the lot specific qualitycontrol certificate.

The variation of OD-values of the standard serum may not be higher than 20%.

If these criteria are not met, the test is not valid and must be repeated.

## 8.2 Cut-off Calculation

A lot specific quality control certificate is included in the test kit so that the obtained OD values can be interpreted qualitatively. The substrate blank must be subtracted from all OD values prior to evaluation.

To fix the cut-off ranges multiply the mean value of the measured standard OD with the lot specific correction factor from the quality certificate. Then add and subtract the lot specific grey zone percentage mentioned on the quality certificate to obtain the upper and lower cut-off. The following numbers are an example only, the valid data you will find in the lot-specific QC certificate which comes with each kit.

Lot specific correction factor: 0.805.      Lot specific grey zone: 15%

If the measured mean absorbance value of the standard serum is 0.84 OD, the range of the cut-off is: Lower cut-off:  $(0.84 * 0.805) - 15\% = \text{OD } 0.575$   
Upper cut-off:  $(0.84 * 0.805) + 15\% = \text{OD } 0.778$

### 8.3 Borderline Ranges

The borderline range indicates the range for borderline test results. Values obtained, when testing a sample, which fall below this range indicate a negative test result; values above the borderline range are interpreted positive. In cases where the results are within the borderline range a definitive interpretation of the result is not possible. In such cases, the test should be repeated in parallel with a follow-up sample taken one to two weeks later (serum pair).

## 9 PERFORMANCE CHARACTERISTICS

### 9.1 Sensitivity and Specificity

The IBL-America Bordetella pertussis IgA, IgG, and IgM ELISA was verified in an internal study. The specificity exceeded 99% for the IgA, IgG, and IgM. The sensitivity exceeded 99% for the IgA and IgG and was 88.9% for the IgM.

### 9.2 Reproducibility

#### Bordetella pertussis IgA ELISA:

Sample	Mean Value (OD)	Intraassay CV (%)	Mean Value (OD)	Interassay CV (%)
Sample 1	0.480	7.9	0.563	7.4
Sample 2	1.827	4.1	2.022	3.6
Sample 3	2.008	6.0	2.177	4.2

#### Bordetella pertussis IgG ELISA:

Sample	Mean Value (OD)	Intraassay CV (%)	Mean Value (OD)	Interassay CV (%)
Sample 1	0.397	5.4	0.446	12.4
Sample 2	1.133	3.4	1.188	7.3
Sample 3	1.786	1.6	1.806	4.4

### **Bordetella pertussis IgM ELISA:**

<b>Sample</b>	<b>Mean Value (OD)</b>	<b>Intraassay CV (%)</b>	<b>Mean Value (OD)</b>	<b>Interassay CV (%)</b>
Sample 1	0.512	5.5	0.479	9.6
Sample 2	0.551	4.6	0.516	14.2
Sample 3	0.984	4.8	0.962	15.9

### **9.3 Cross-reactivities**

#### **Bordetella pertussis IgA:**

To determine detection of cross-reactive antibodies directed against different parameters sera were analyzed with Bordetella pertussis IgA and a commercially available anti-Bordetella pertussis IgA ELISA. Positive sera (10 sera each) for Adenovirus IgA, Helicobacter pylori IgA, Mycoplasma pneumoniae IgA, Parainfluenza Virus IgA, Influenza A Virus IgA, and Influenza B Virus IgA have been tested as well as sera positive for rheumatoid factor (RF) and anti-nuclear antibodies (ANA). Within this internal evaluation potential cross-reactivities with RF positive sera, one ANA sample, one Adenovirus, one Helicobacter pylori, two Mycoplasma pneumoniae and one Parainfluenza Virus IgA positive sera have been observed. All reactivities have been confirmed by positive or borderline results in the reference assay. Other cross-reactivities cannot be ruled out in general.

#### **Bordetella pertussis IgG:**

To determine detection of cross-reactive antibodies directed against different parameters sera were analyzed with Bordetella pertussis IgG and a commercially available anti-Bordetella pertussis IgG ELISA. Positive sera (10 sera each) for Adenovirus IgG, Helicobacter pylori IgG, Mycoplasma pneumoniae IgG, Parainfluenza Virus IgG, Influenza A Virus IgG, and Influenza B Virus IgG have been tested as well as sera positive for rheumatoid factor (RF) and anti-nuclear antibodies (ANA). Within this internal evaluation potential cross-reactivities with one Adenovirus, one Parainfluenza Virus, three Influenza A and B Virus positive serum and RF and two ANA samples have been observed. All reactivities have been confirmed by positive or borderline results in the reference assay. Other cross-reactivities cannot be ruled out in general.

#### **Bordetella pertussis IgM:**

To determine detection of cross-reactive antibodies directed against different parameters sera were analyzed with Bordetella pertussis IgM and a commercially available anti-Bordetella pertussis IgM ELISA. Positive sera (10 sera each) for Helicobacter pylori IgM, Mycoplasma pneumoniae IgM, Parainfluenza Virus IgM, Influenza A Virus IgM, and

Influenza B Virus IgM have been tested as well as sera positive for rheumatoid factor (RF) and anti-nuclear antibodies (ANA). Within this internal evaluation potential cross-reactivities with one Mycoplasma pneumoniae IgM have been observed. Other cross-reactivities cannot be ruled out in general.

## **9.1 Interfering Substances**

### **Bordetella pertussis IgA/IgG/IgM:**

To determine the influence of interfering substances, sera with different reactivities were analyzed with the Bordetella pertussis IgA/IgG/IgM ELISA. No interferences have been detected for sera with concentrations up to 2.00 g/L hemoglobin, 11.50 g/L lipemia/triglyceride oder 0.201 g/L bilirubin (conjugated and unconjugated).

## **10 SAFETY MEASURES**

### **10.1 Statements of Warning**

The IBL-America ELISA test kits are designed for use by qualified personnel who are familiar with good laboratory practice. All kit reagents and samples should be handled carefully, using established good laboratory practice.

- This kit contains human blood components. Although all control- and cut-off sera have been tested and found negative for anti-HIV-ab, HBs-Ag (*Hepatitis B-Virus-surface Antigen*) and anti-HCV-ab, they should be considered potentially infectious.
- Do not pipette by mouth.
- Do not smoke, eat or drink in areas in which specimens or kit reagents are handled.
- Wear disposable gloves, laboratory coat and safety glasses while handling kit reagents or specimens. Wash hands thoroughly afterwards.
- Sample material and other potentially infectious material should be decontaminated after the test run.
- Reagents should be stored safely and be inaccessible to unauthorized access e.g. children.

### **10.2 Disposal**

Please observe the relevant statutory requirements!



## 11 REFERENCES

- [1] Aase A. *et al.* (2007) Opsonophagocytic Activity and Other Serological Indications of *Bordetella pertussis* Infection in Military Recruits in Norway. *Clin. Vac. Immunol.* 14, 855-62.
- [2] Baughman *et al.* (2004) Establishment of Diagnostic Cut off Points for Levels of Serum Antibodies to Pertussis Toxin, Filamentous Hemagglutinin, and Fimbriae in Adolescents and Adults in the United States. *Clin. Diagn. Lab. Immunol.* 11, 1045-53.
- [3] de Melker, H. E., Versteegh, F. G., Conyn-Van Spaendonck, M. A., Elvers, L. H., Berbers G. A., van Der Zee, A., Schellekens, J. F. (2000) Specificity and sensitivity of high levels of immunoglobulin G antibodies against pertussis toxin in a single serum sample for diagnosis of infection with *Bordetella pertussis*. *J. Clin. Microbiol.* 38, 800-6.
- [4] Granström, G., Wretling, B., Salenstedt, C.-R., Granström, M. (1988) Evaluation of serologic assay for diagnosis of whooping cough. *J. Clin. Microbiol.* 26, 1818-23.
- [5] Kösters, K., Riffelmann, M., Dohrn, B., Wirsing von König, C.-H. (2000) Comparison of five commercial enzyme-linked immunosorbent assays for detection of antibodies to *Bordetella pertussis*. *Clin. Diagn. Lab. Immunol.* 7, 422-6.
- [6] Müller, F.-M. C., Hoppe, J. E., Wirsing von König, C.-H. (1997) Laboratory diagnosis of pertussis: State of the art in 1997. *J. Clin. Microbiol.* 35, 2435-43.
- [7] Pebody R.G. *et al.* (2005) The seroepidemiology of *Bordetella pertussis* infection in Western Europe. *Epidemiol. Infect.* 133, 159-71.
- [8] Xing D. *et al.* (2009) Characterization of reference materials for human antiserum to pertussis antigens by an international collaborative study. *Clin. Vac. Immunol.* 16, 303-11.